



## Eco-friendly injection locked laser with flexible power for double patterning ArF immersion lithography

Takashi Matsunaga, Hiroshi Umeda, Satoshi Tanaka, Hiroaki Tsushima, Yasufumi Kawasuji, Hiroshi Tanaka, Hidenori Watanabe, Masaya Yoshino, Shinichi Matsumoto, Junichi Fujimoto, Hakaru Mizoguchi

Gigaphoton Inc.



## Contents

- INTRODUCTION
  - ✓ ArF Roadmap
  - ✓ ArF Specifications
- EcoPhoton Concept
  - ✓ EcoPhoton Roadmap
- Technology
  - ✓ CoE reduction
  - ✓ CoC reduction
  - ✓ CoD reduction
- CONCLUSION



## Contents

- INTRODUCTION
  - ✓ ArF Roadmap
  - ✓ ArF Specifications
- EcoPhoton Concept
  - ✓ EcoPhoton Roadmap
- Technology
  - ✓ CoE reduction
  - ✓ CoC reduction
  - ✓ CoD reduction
- CONCLUSION

# INTRODUCTION

- **ArF immersion technology has been used widely in volume production for 45nm node.**
- **For 32nm node and beyond, double patterning technology with ArF immersion lithography is considered to be the main stream solution until EUV becomes ready.**
- **GPI aims to develop an ‘ Eco-friendly ’ laser. It not only reduces CoC (Cost of Consumable) and CoD (Cost of Downtime); it offers ecological performances to reduce CoE (Cost of Energy) such as electric power or gas consumption.**
- **GPI has released the tunable output power (60W - 90W) laser GT62A-1SxE under ‘EcoPhoton’ concept, which meets the specification of the advanced illumination system .**
- **Technologies supporting this concept will be reported in this presentation.**

# ArF Laser Roadmap

Power	Technology Node	Main driver	Requirement for ArF Laser	~2004	2005	2006	2007	2008	2009	2010	2011		
60 - 90W	32 nm	double patterning higher throughput (advanced system)	6kHz/60-90W/0.30pm(E95)										GT62A-1SxE
90W	32 nm	double patterning higher throughput	6kHz/90W/0.30pm(E95)										GT62A-1N
60W	32 nm	double patterning higher throughput	6kHz/90W/0.30pm(E95)										GT62A-1S
60W	45 nm	higher NA	6kHz/60W/0.30pm(E95)										GT61A
60W	50 nm	higher throughput higher NA	6kHz/60W/<0.50pm(E95)										GT60A
45W	65 nm	higher throughput	4kHz/45W/<0.50pm(E95)										GT40A
													GT40A-2

# Specifications

ArF model		GT40A	GT60A	GT61A	GT62A-1S	GT62A-1N	GT62A-1SxE
Wavelength	nm	193	193	193	193	193	193
Power	W	45	60	60	60	90	60 - 90
Pulse energy	mJ	11.25	10	10	10	15	10 - 15
Max. rep rate	Hz	4000	6000	6000	6000	6000	6000
FWHM	pm	0.2	0.2	N.A	N.A	N.A	N.A
E95	pm	<0.5	<0.5	0.3	0.3	0.3	0.3
Durability (Expected)							
MO Chamber	Bpls	40*	40*	40*	40*	40*	>40***
PO Chamber	Bpls	40*	40*	40*	40*	40*	>40***
LNM / MO LNM	Bpls	60**	60**	60**	60**	60**	60**
MM	Bpls	30	30	30	30	30	30
FM / PO FM	Bpls	30	30	30	30	30	30
PO RM	Bpls	30	30	30	30	30	30

\* GRYCOS technology

\*\* MPL (Multi Positioning LNM)

\*\*\* Durability can be extendable @ <90W

**GT62A-1SxE meets the requirements for the advanced exposure systems.**



## Contents

- INTRODUCTION
  - ✓ ArF Roadmap
  - ✓ ArF Specifications
- EcoPhoton Concept
  - ✓ EcoPhoton Roadmap
- Technology
  - ✓ CoE reduction
  - ✓ CoC reduction
  - ✓ CoD reduction
- CONCLUSION

## EcoPhoton concept

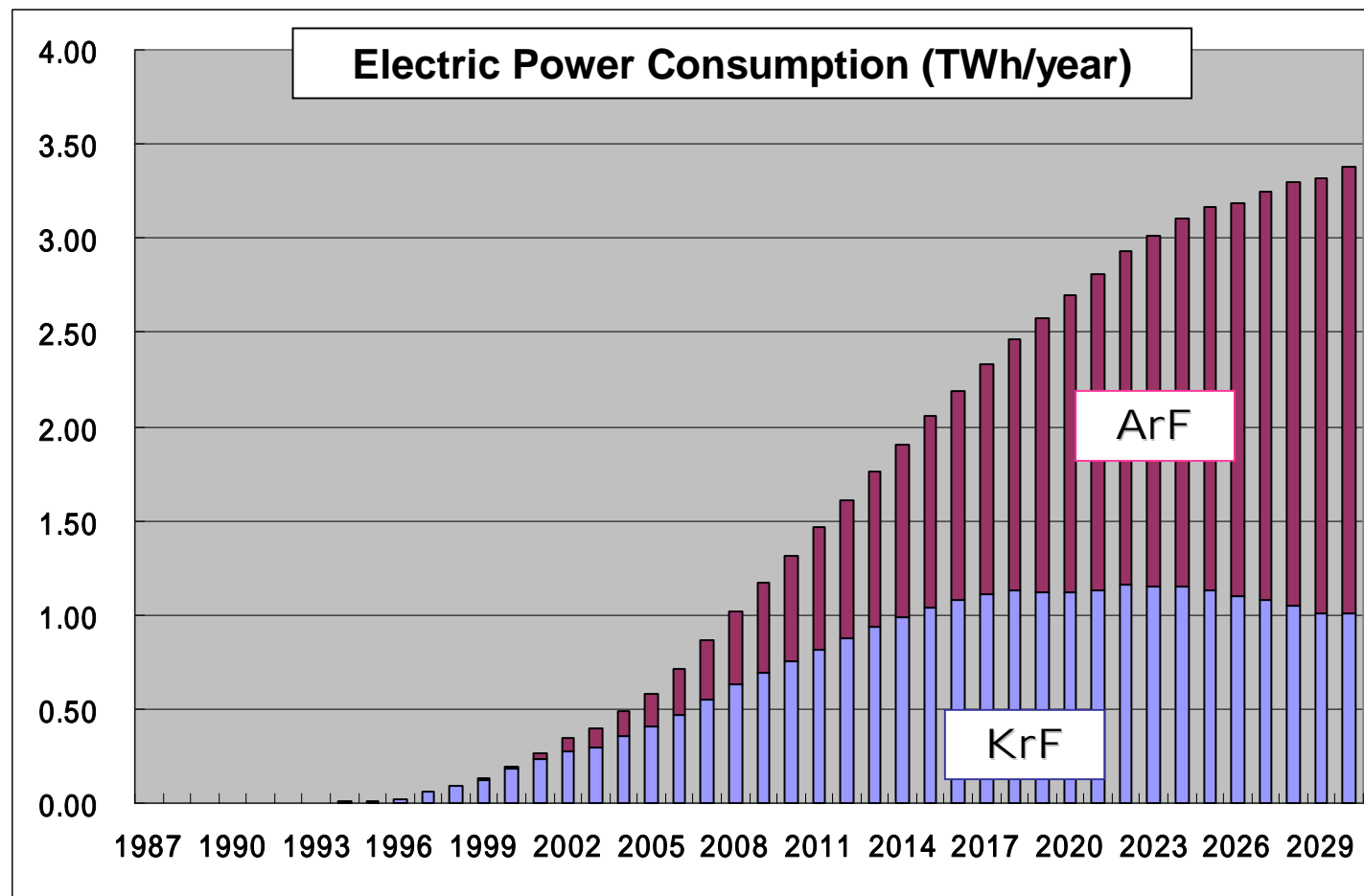
- GPI develops and releases 'Eco-friendly' laser. it not only reduces CoC (Cost of Consumable) and CoD (Cost of Downtime); it offers ecological performances to reduce CoE (Cost of Energy) such as electric power or gas consumption.
- EcoPhoton is the total cost reduction roadmap with more comprehensive scope including impact on environment.
- This year GPI has revealed a new cost reduction roadmap under EcoPhoton concept.





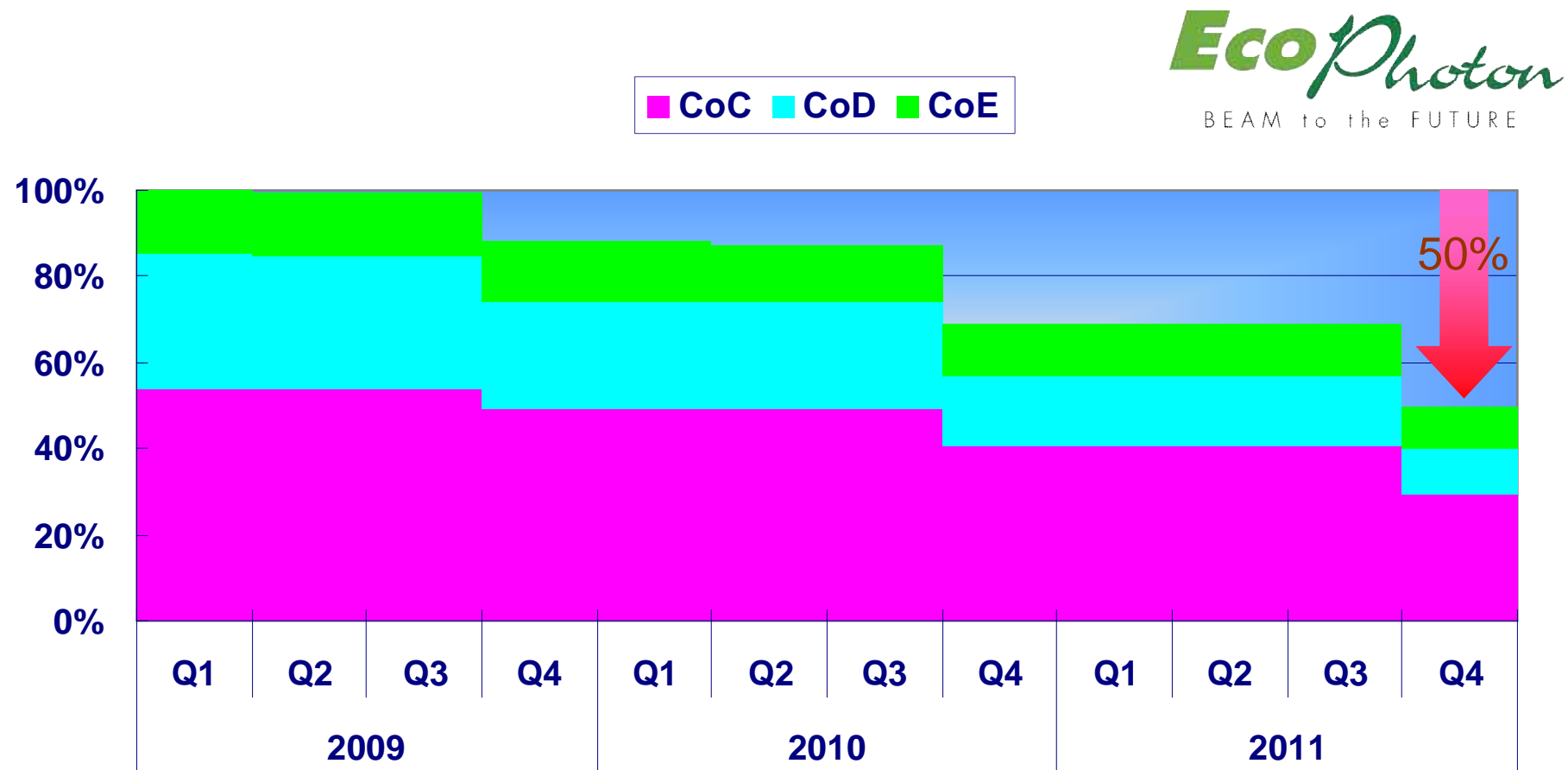
## Electric Power Consumption by Excimer Lasers for Lithography – World Wide Estimation

- Electric power consumption by excimer lasers exceeds 1T·Wh/year and is estimated to increase to over 3T·Wh/year within fifteen years.



# EcoPhoton roadmap

- GPI target is over 50 % cost reduction before Y2012\*



\* Based on EcoPhoton policy



## Contents

- INTRODUCTION
  - ✓ ArF Roadmap
  - ✓ ArF Specifications
- EcoPhoton Concept
  - ✓ EcoPhoton Roadmap
- Technology
  - ✓ CoE reduction
  - ✓ CoC reduction
  - ✓ CoD reduction
- CONCLUSION

New product

## GT62A-1S xE



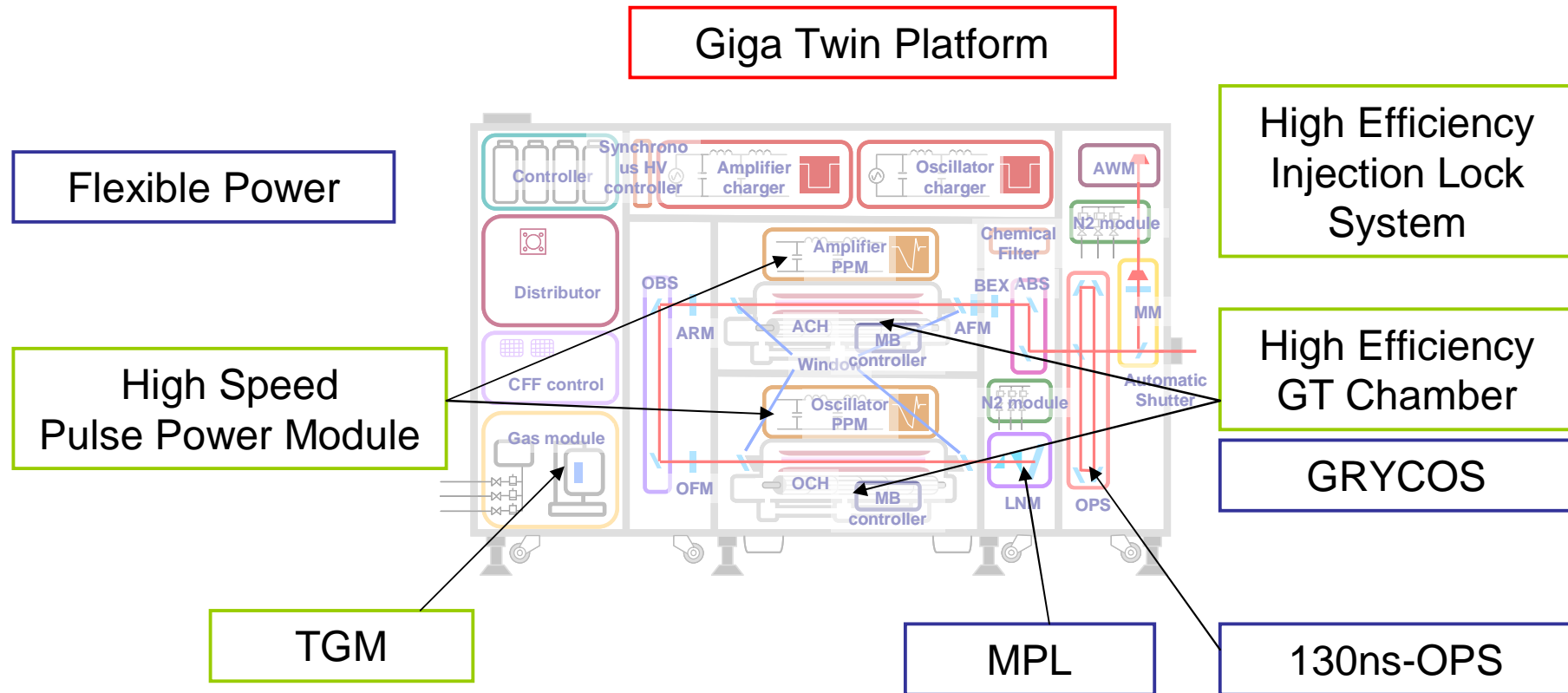
- GT62A-1S xE
  - ✓ Meeting the advanced illumination system
  - ✓ Optimized illumination power for various resist sensitivities
- Features
  - ✓ 90W module
    - Chamber / OPS / MM / Others
  - ✓ Flexible power
    - Max 90W operation
    - Easy Upgrade
    - Durability extension <90W
  - ✓ Long pulse duration

# Technology for EcoPhoton in GT62A-1S xE

CoE Reduction

CoC Reduction

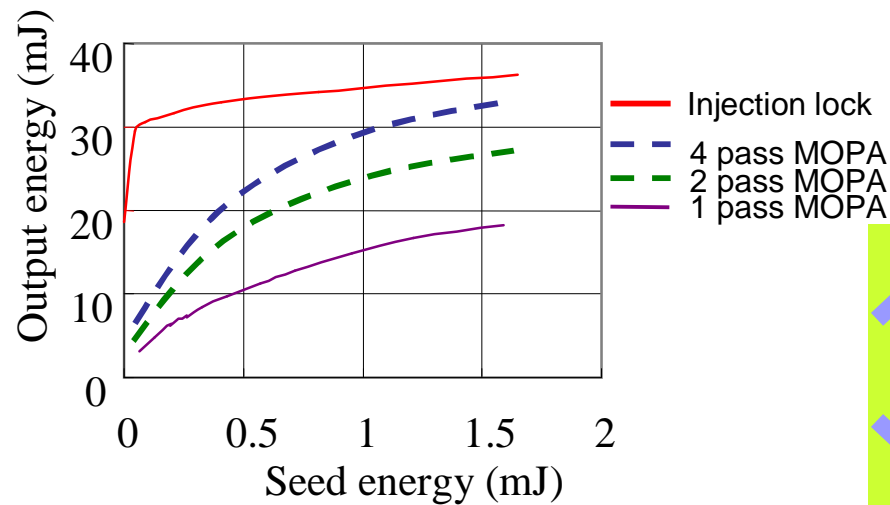
CoD Reduction



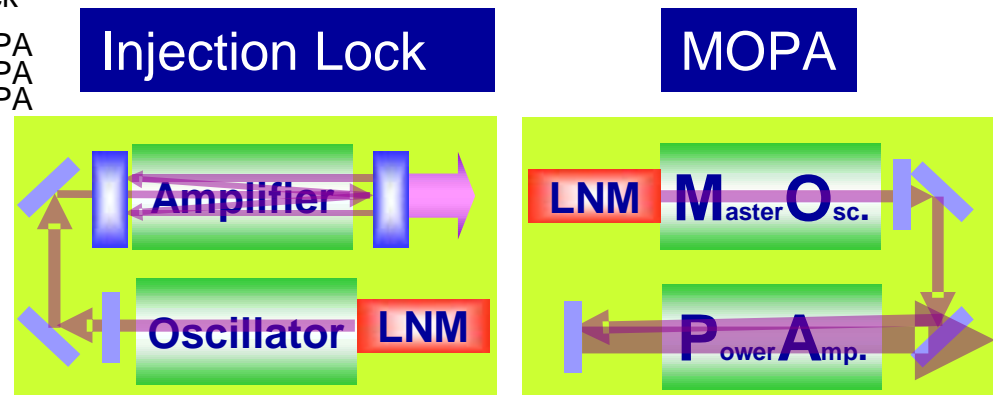
# Technology for CoE Reduction

## High Efficiency Injection Lock System

- Injection Lock system has a resonator in an amplifier.
- It can generate higher laser energy with less seed energy than MOPA system.

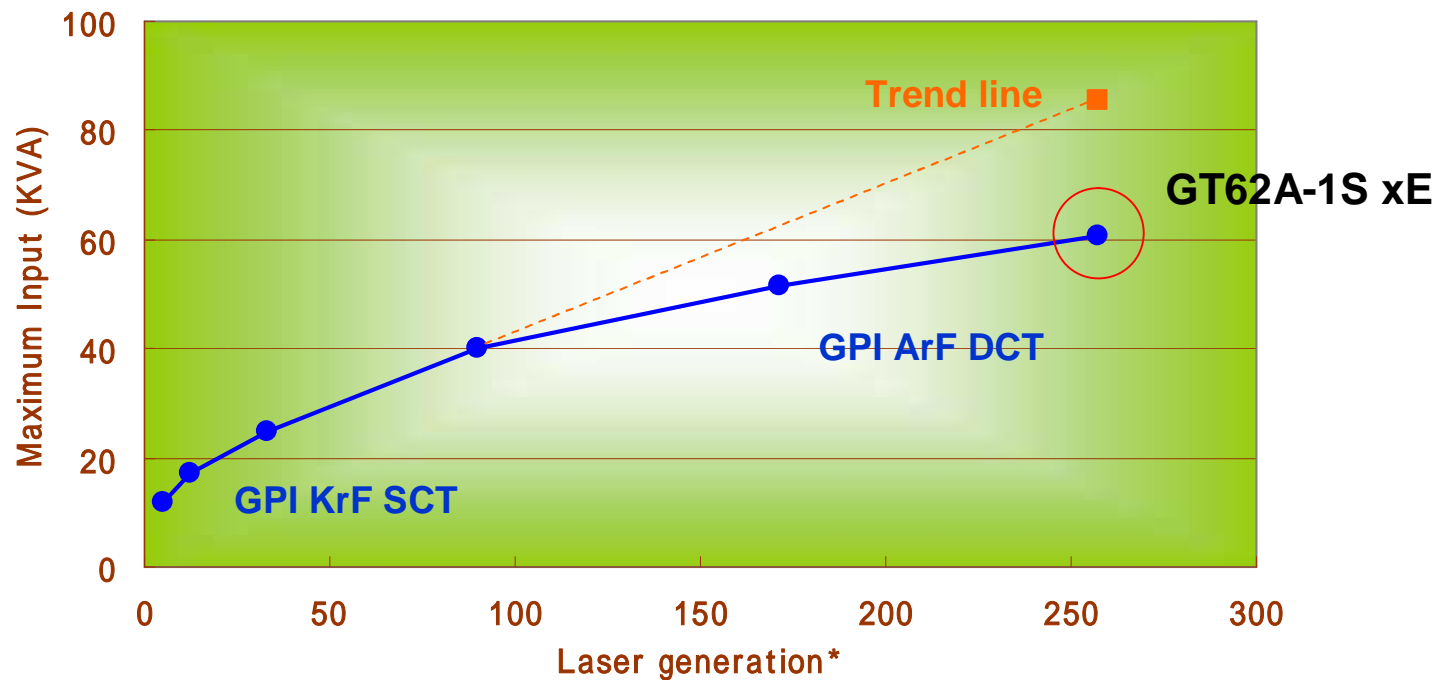


(experiment data in Gigaphoton)



## Electric consumption history

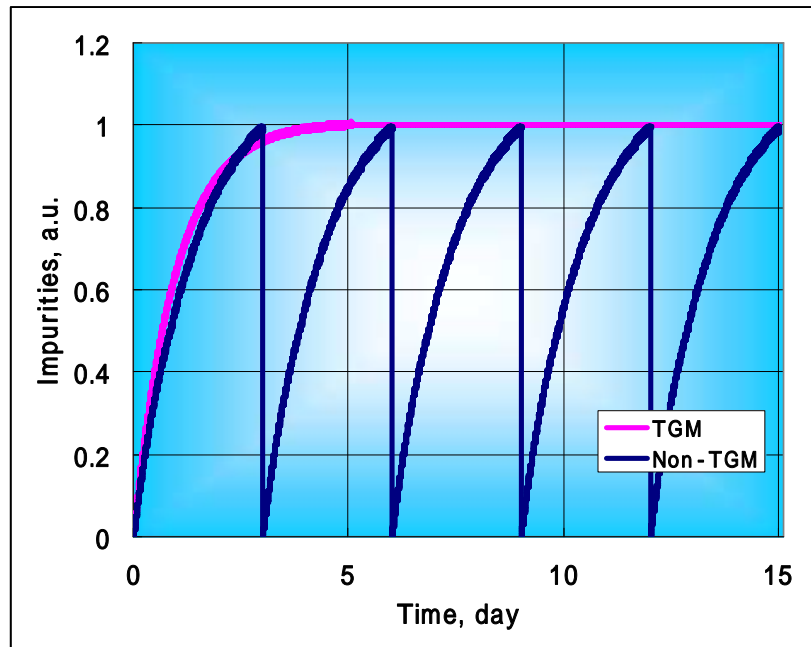
- Gigaphoton has been paying attention to ecology for the past years, and has been successful to develop efficient lasers below trend line.



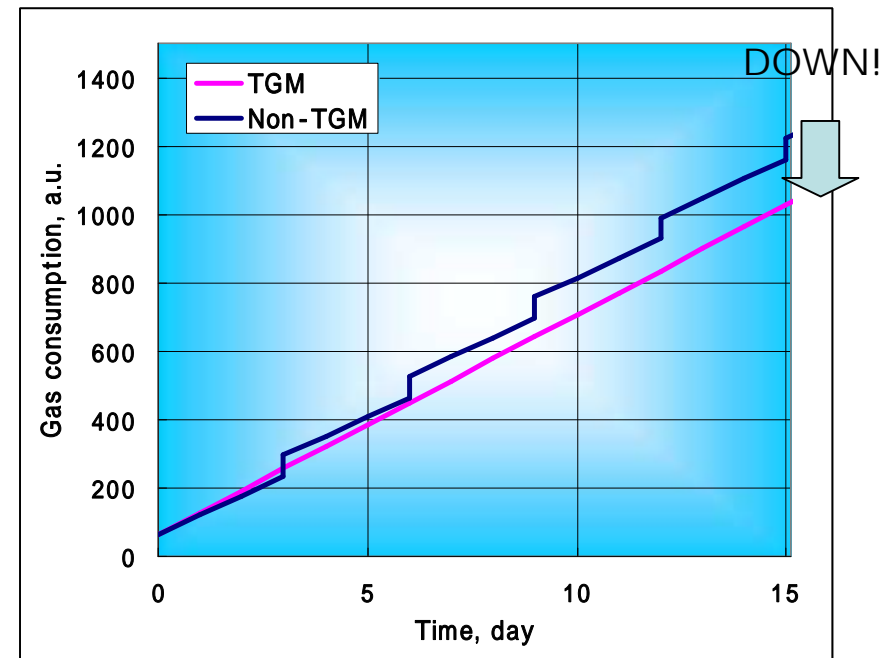
\* Laser generation estimate from laser specification, Output power / spectrum

## TGM (Total Gas Management)

- Gas refill interval extends remarkably (3days → 15days : 24times/year).
- Gas consumption is reduced more than that under conventional gas control.



Impurities in chamber



Gas consumption

Simulation condition:  
 -Initial Gas pressure 220kPa  
 -Duty 10%  
 -Repetition rate 6000Hz

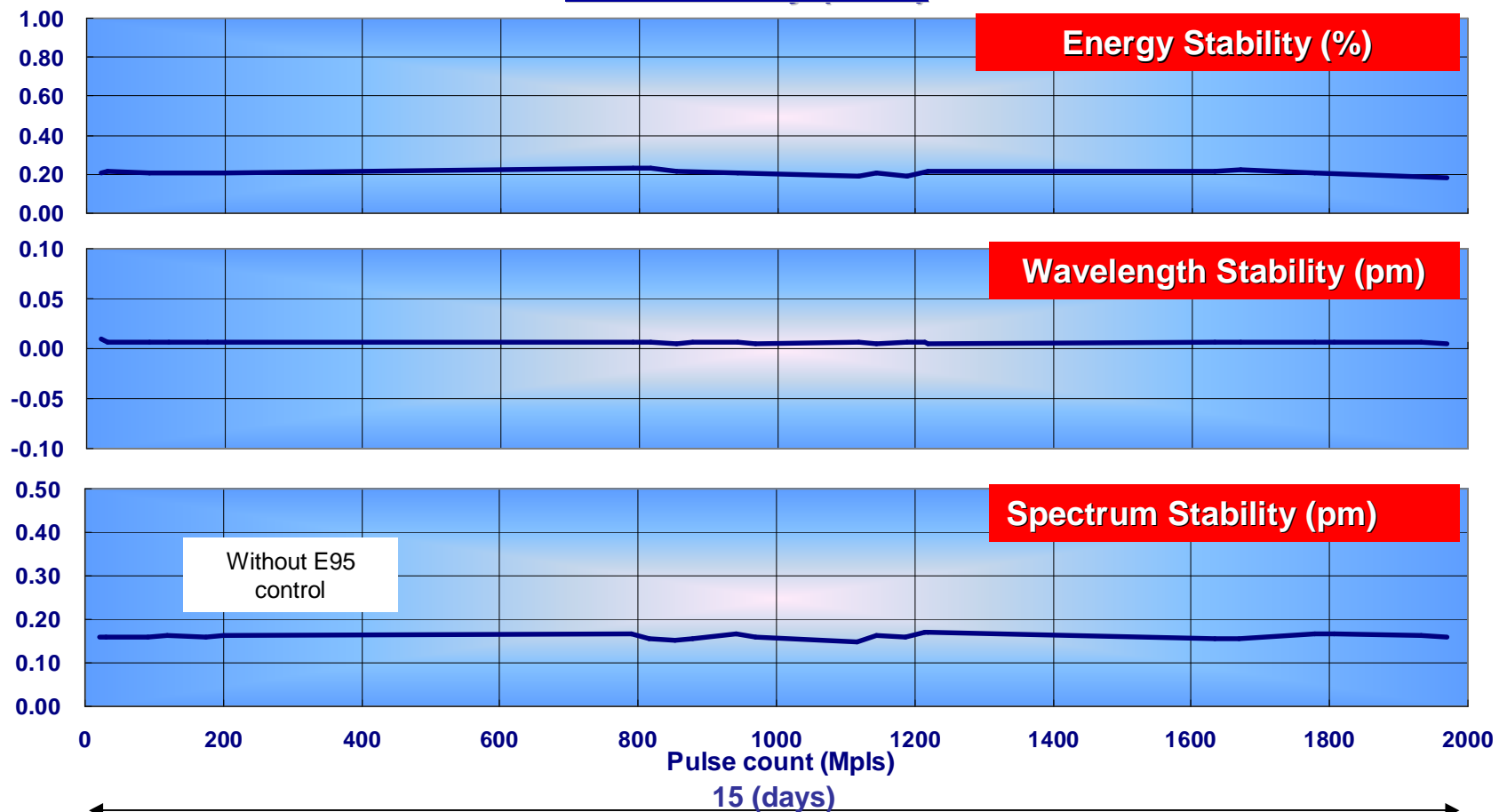


### Improved Gas Control

- ✓ Stabilization of fluorine partial pressure
- ✓ Reduction of the amount of impurity

Beam Quality is stable during extended gas lifetime.

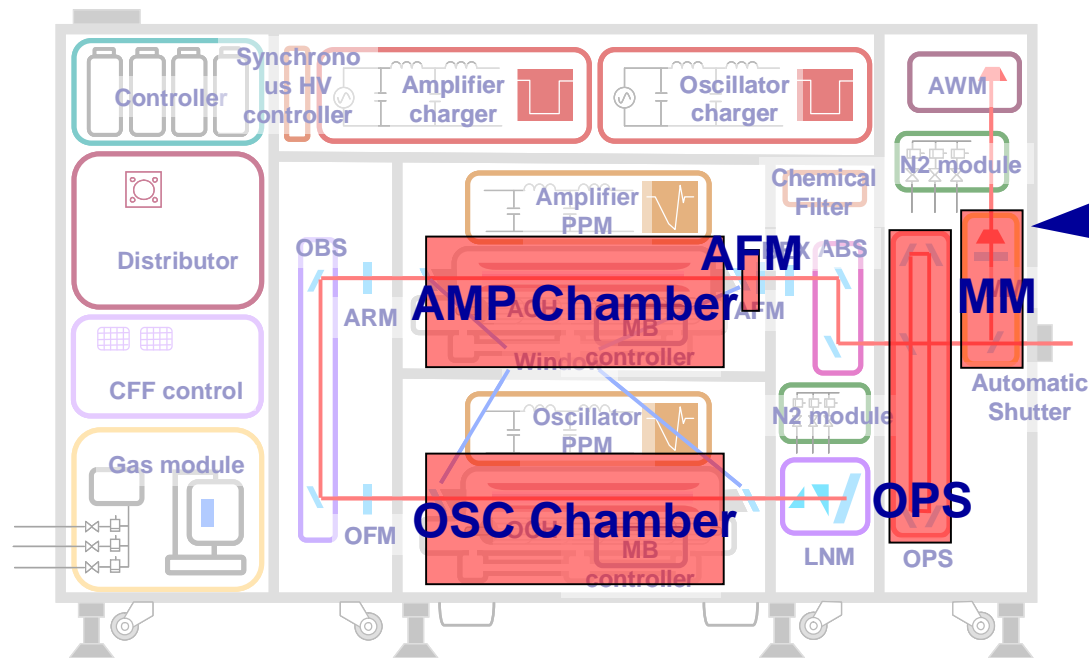
### Beam Quality (TGM)



# Technology for CoC Reduction

## Flexible Power

- Illumination Power optimum for Resist Sensitivity is provided.
  - ✓ Power extension from 60W to 90W
- Consumable lifetime extends at under 90W operation



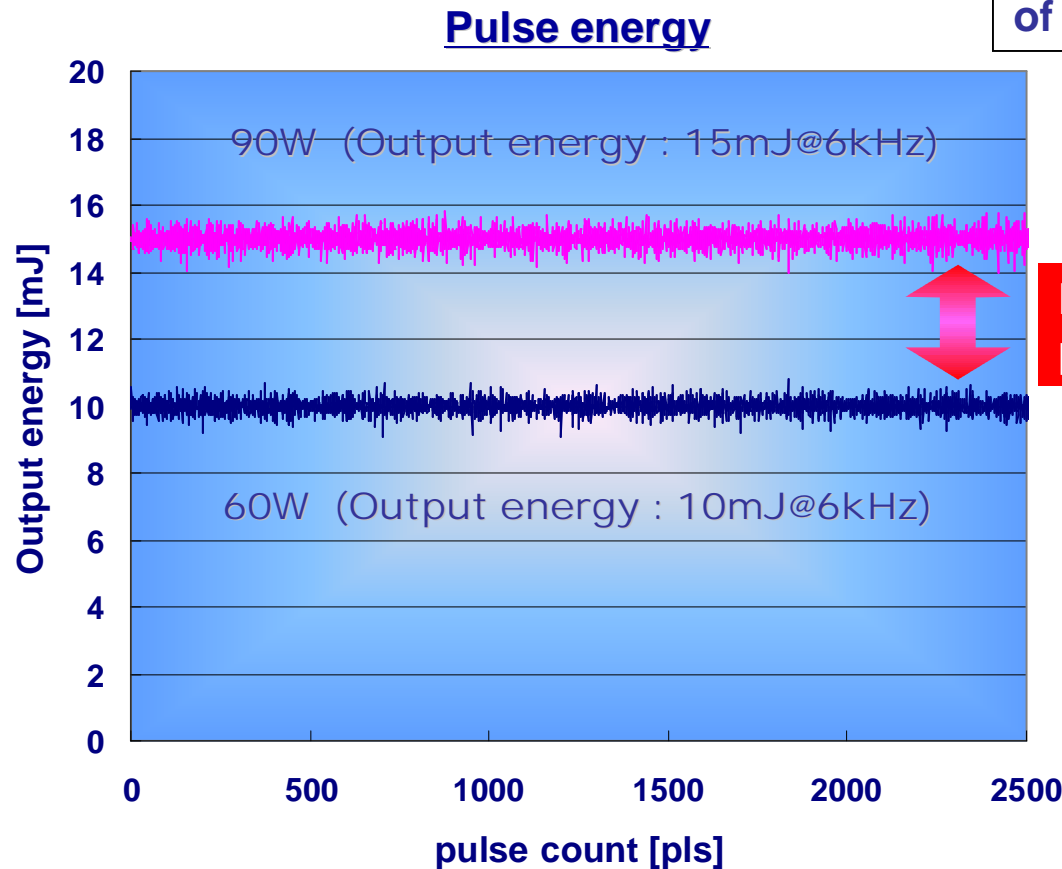
90W modules  
2\* Chamber  
MM  
AFM  
OPS  
+small parts

\* New OPS required for 90W operation only

## Flexible Power

- Introduction of 90W technology modules
  - ✓ Up to 90W operation capable
  - ✓ SW switch to change operation power

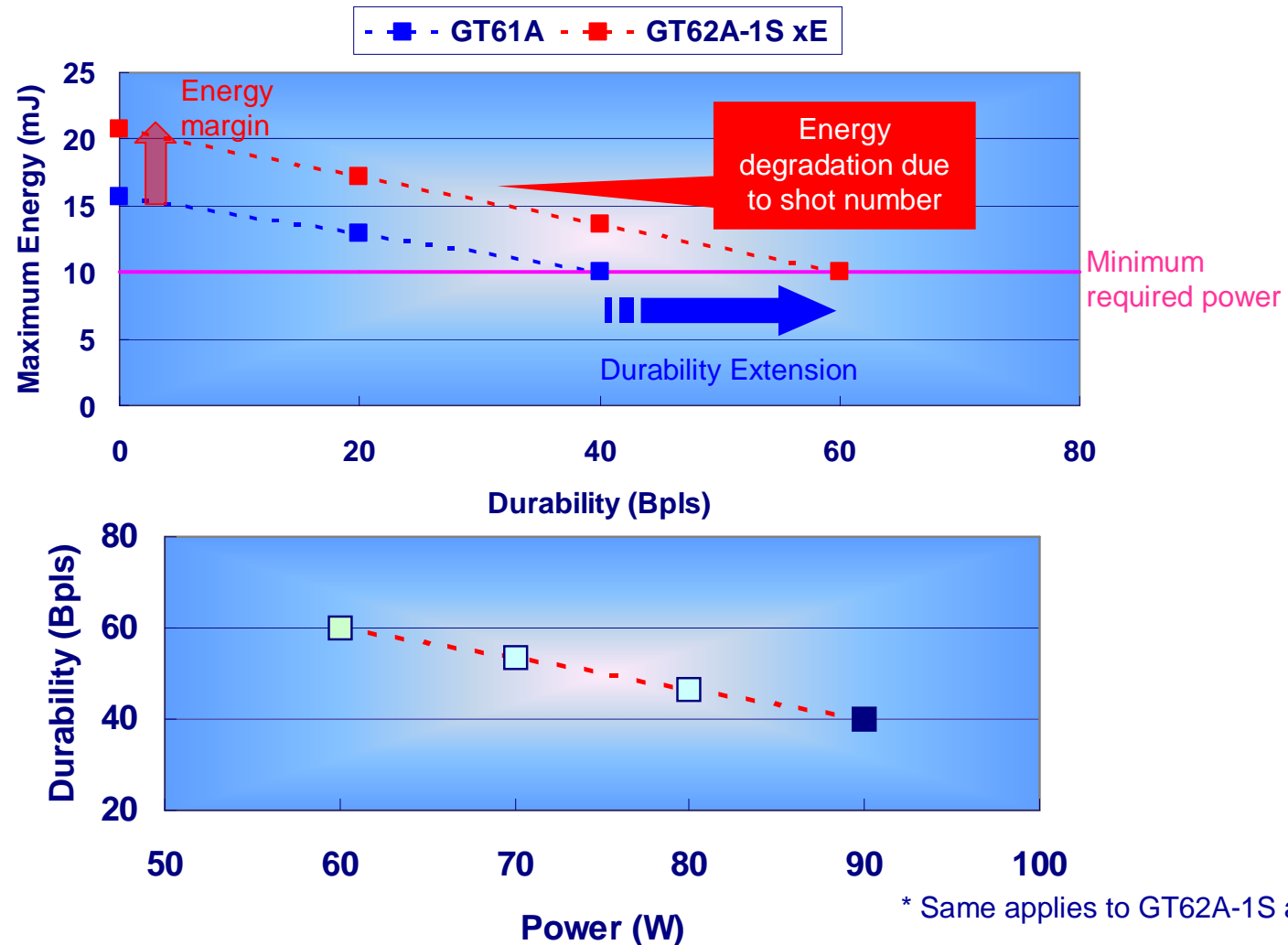
Feed-back the various technologies of 90W in the 60W laser.



Flexibility of the lithography processes can be increased.

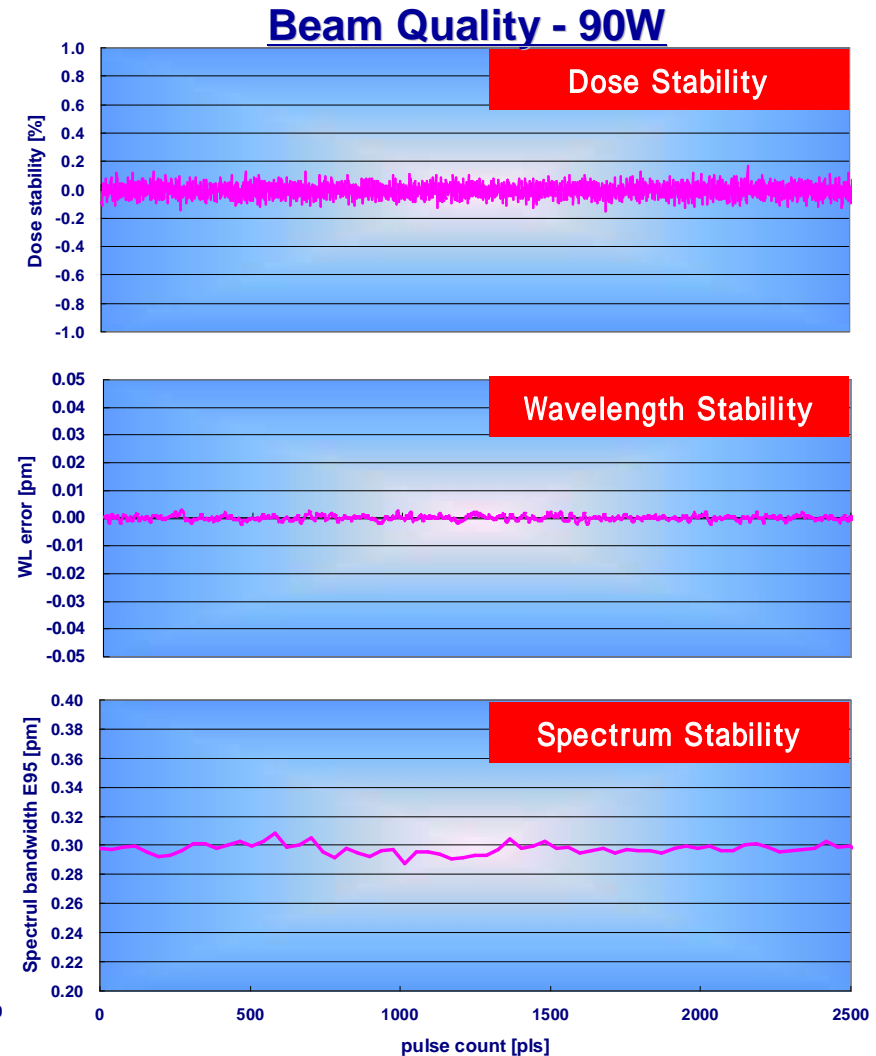
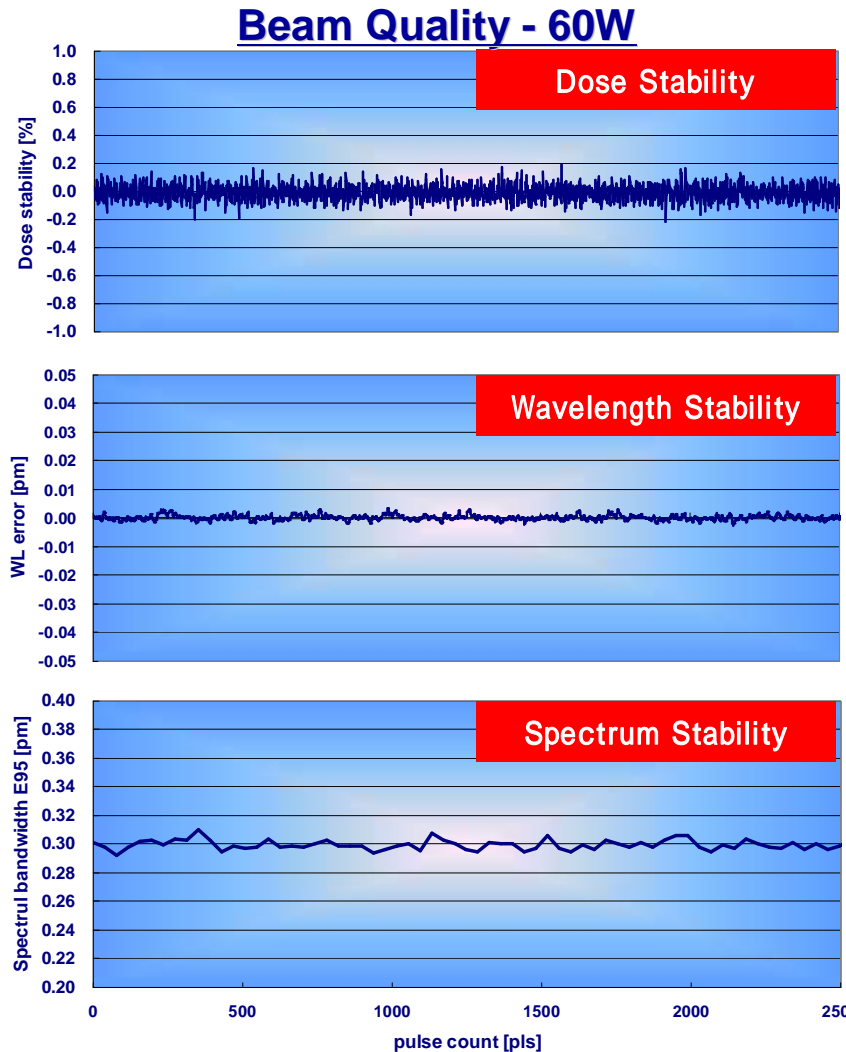
## Consumable lifetime extension

- 90W ready power supply can provides durability extension <90W operation



# Performance

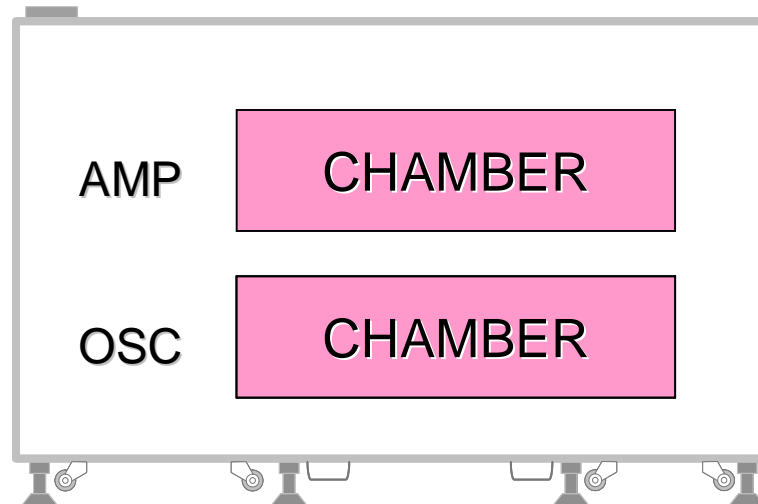
- Beam Quality related to CD variation is kept stable in Power extension.



# GRYCOS (Gigaphoton RecYcle Chamber Operating System)

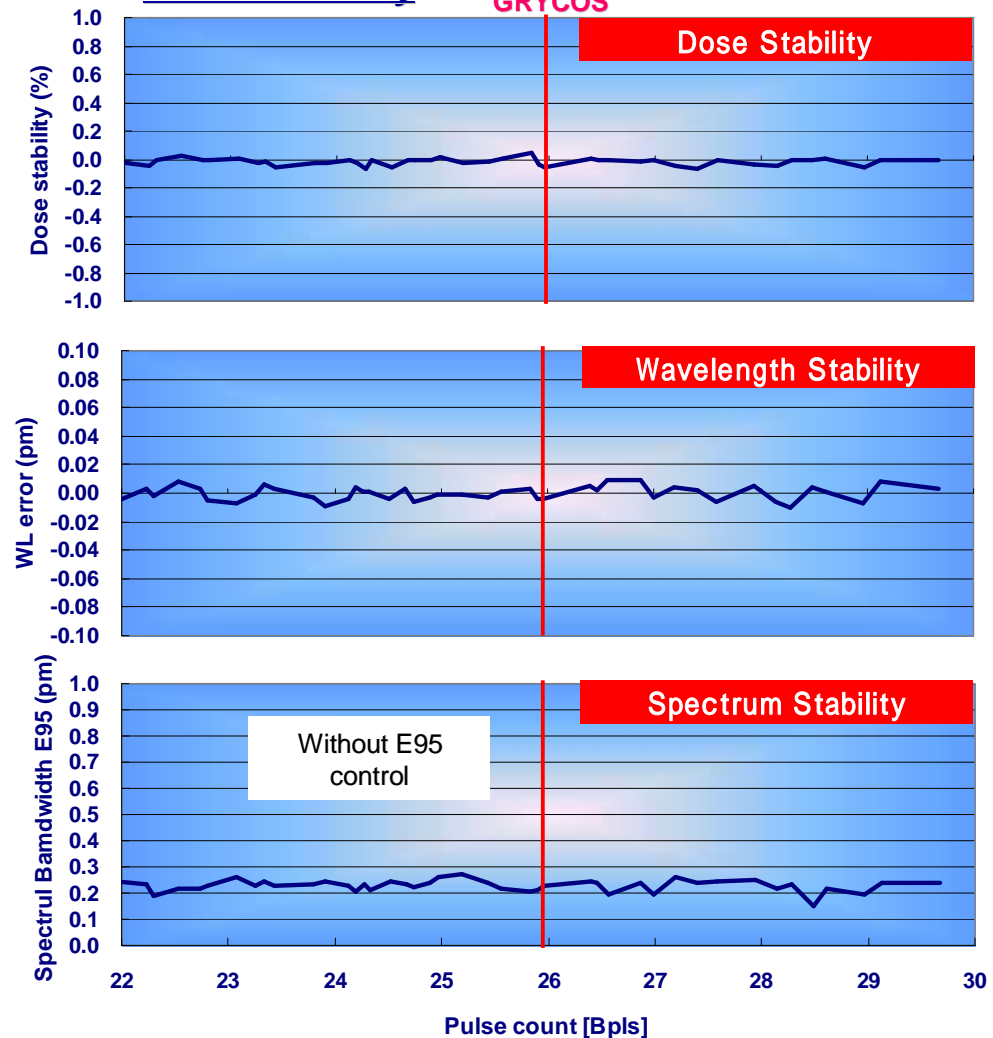
➤ Each laser chamber can be used up to 40Bpls.

Used oscillator chamber use as amplifier chamber



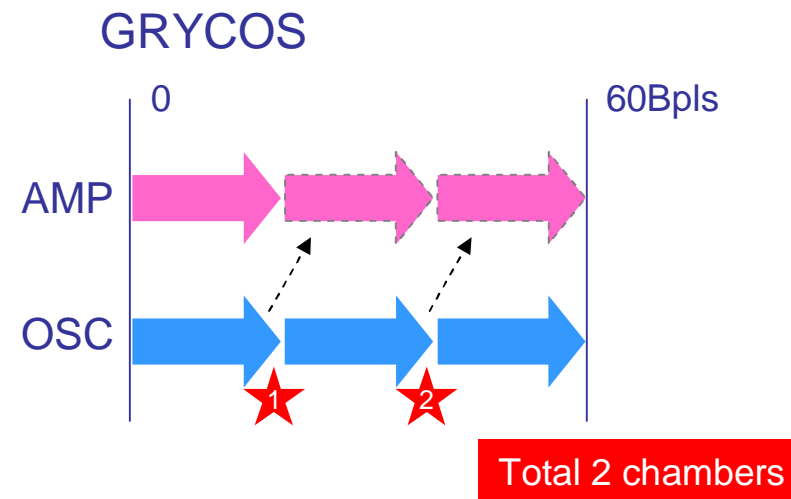
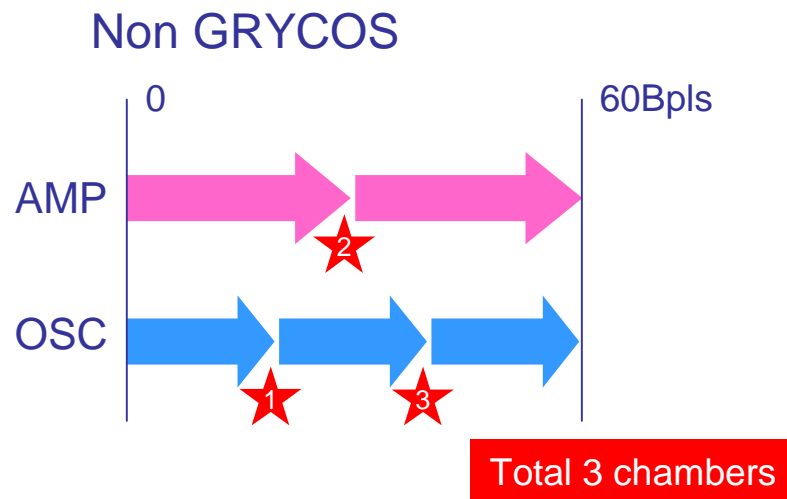
**No impact to Beam Quality**

**Beam Quality**



## Cost simulation

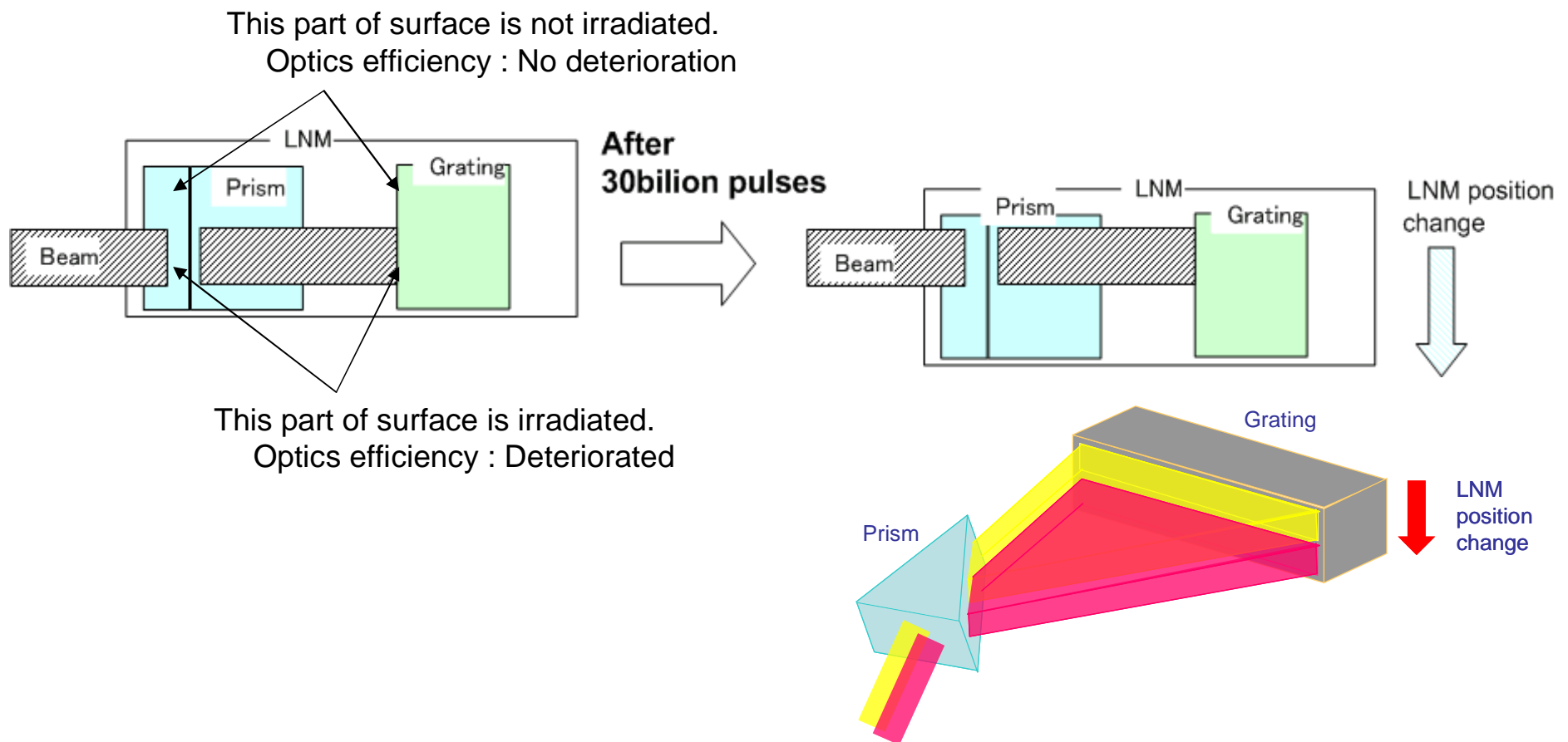
- GRYCOS can reduce number of chamber replacement, i.e. can drastically reduce CoO
  - ✓ For example, 60Bpls laser usage
    - 1 chamber can be reduced
    - GRYCOS merit can be calculated as 1/2 chamber cost in each GRYCOS



# MPL (Multi Positioning LNM)

➤ LNM life time extends to double (30Bpls → 60Bpls).

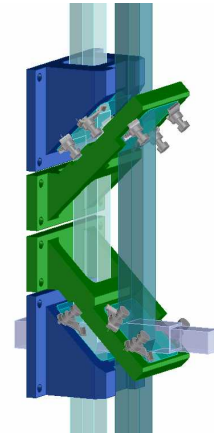
Effectively changing optical pass



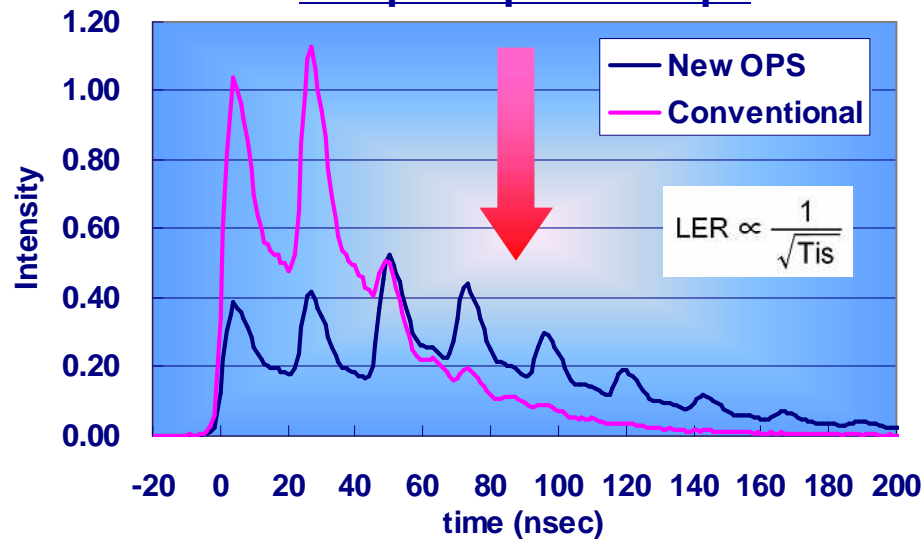


# 130ns-OPS (130ns-Optical Pulse Stretcher)

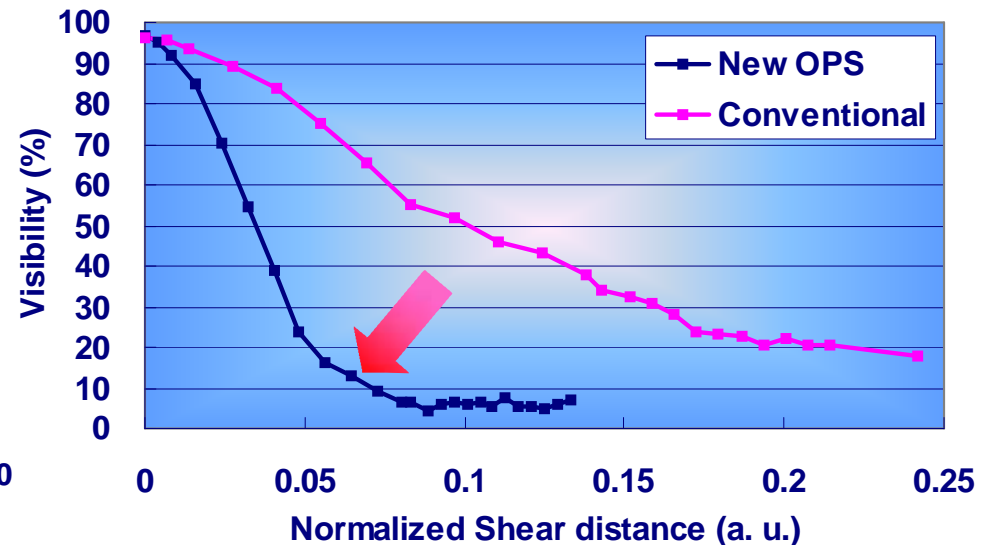
- New OPS (Optical Pulse Stretcher) developed for >60W operation
  - ✓ 2 stage pulse stretch :  $T_{is} = 130\text{ns}$
- Advantage of New OPS
  - ✓ Lower peak power slows down optics deterioration
  - ✓ Reduce Spatial/Temporal coherence



**Temporal pulse shape**



**Spatial coherence**

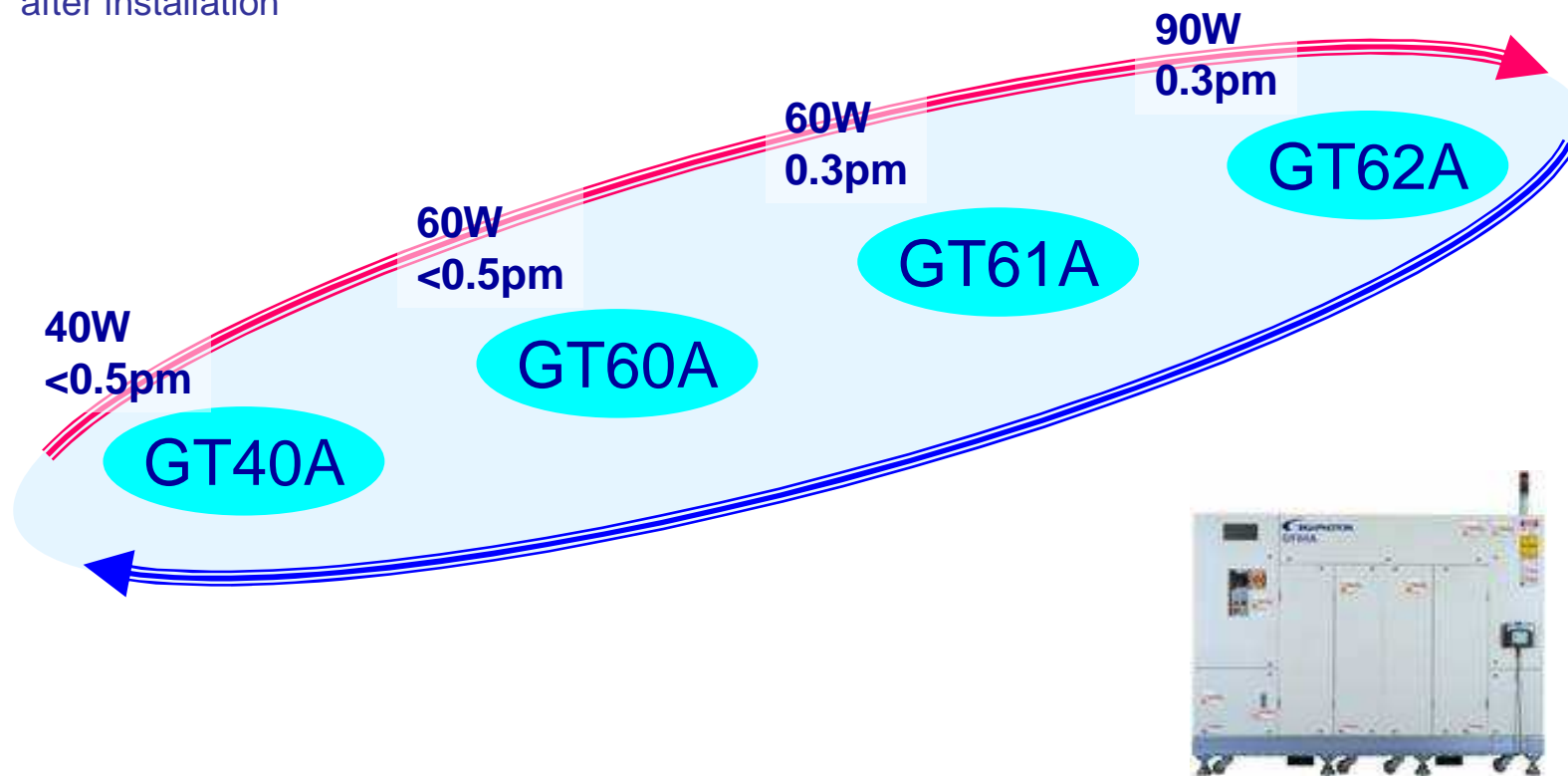


\* Measured by Shearing interferometer

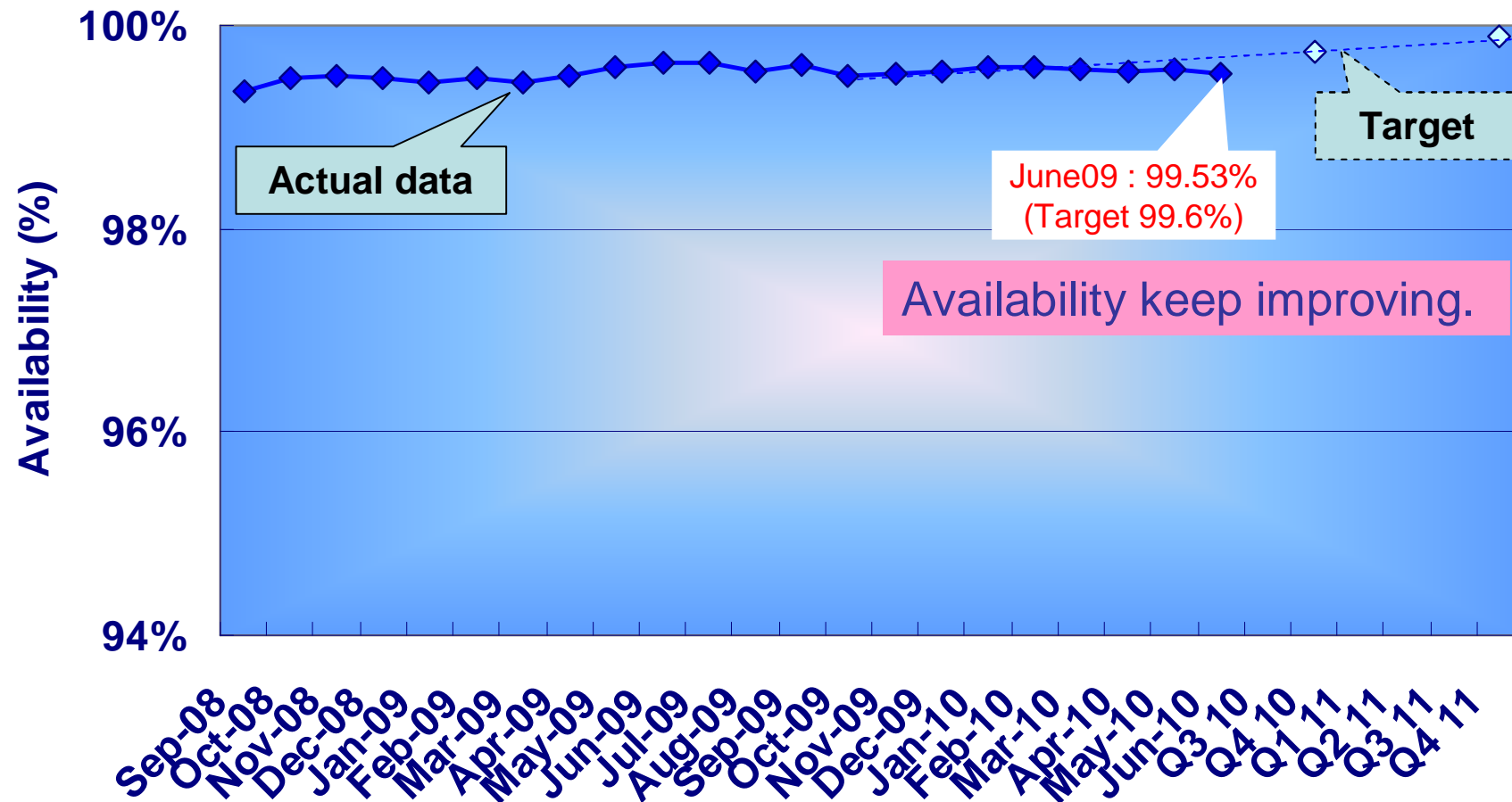
# Technology for CoD Reduction

## Giga Twin Platform

- Performance improvement
  - ✓ Develop new technology quickly
- Inherited Reliability
  - ✓ Smoothly introduced to a mass-production after installation



## ArF GT6xA, Availability improvement



Data is calculated through 3 month moving window



## Contents

- INTRODUCTION
  - ✓ ArF Roadmap
  - ✓ ArF Specifications
- EcoPhoton Concept
  - ✓ EcoPhoton Roadmap
- Technology
  - ✓ CoE reduction
  - ✓ CoC reduction
  - ✓ CoD reduction
- CONCLUSION

## CONCLUSION

- **GPI has developed and released Eco-friendly laser on 'EcoPhoton' concept.**
- **EcoPhoton is the total cost reduction roadmap with more comprehensive scope including impact on environment.**
- **GPI released GT62A-1S xE. It not only reduces CoC and CoD; it offers ecological performances to reduce CoE such as electric power or gas consumption.**
- **GPI developed advanced technologies which support EcoPhoton concept and they are available for all laser model on GigaTwin Platform.**
  - **Injection Lock System**
  - **TGM/GRYCOS/MPL/130ns-OPS**
  - **Flexible Power**

Gigaphoton's mission is to be the No.1 provider of advanced technology and quality products and to contribute to society as the industry leader.  
We at Gigaphoton aim at being a team of professionals who can build a strong relationship of mutual trust, both within and outside of the company.

Thank you for your attention !

**GIGAPHOTON**  
<http://www.gigaphoton.com>